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EDWARDS

CASE STUDY

# ERGONOMICS

## TACKLING REPETITIVE STRAIN

Ontario
Women's
Directorate

**The Change Agents**

Through the **Change Agents** Program, private sector employers, unions, and associations are working with the Ontario Women's Directorate to implement innovative employment equity initiatives that are furthering the economic status and representation of women in the workforce.

One of the objectives of a **Change Agents** project is to report on these endeavours and, by so doing, add to the body of employment equity knowledge and experience. *Ergonomics: Tackling Repetitive Strain* is one such report.

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*Edwards, an equal opportunity employer, is committed to high standards of business conduct and civic responsibility.*

*In recognition of the company's efforts, the Government of Canada awarded Edwards the gold award for Labour Management Cooperation in 1986. Edwards shared the award with the United Steelworkers of America Local 7466 for their joint effort in converting the Owen Sound plant from an electro-mechanical environment to a high technology operation using the latest automated production facilities. In order to adapt to the competitive marketplace, Edwards was forced to develop an entirely new product line, based on computer technology. Union/management committees were established to troubleshoot changeover problems and to design extensive training programs to retrain the entire production staff.*

*During this period of transition, Edwards continued to develop and implement programs and policies for their employees. Women were promoted to management positions in sales and service in a technical environment that had been exclusively held by men. Women were encouraged to enter "trades" level positions such as Electronic Monitoring Systems Specialist. Under the cooperation and guidance of the Ministry of Colleges and Universities and Canada Employment and Immigration, apprenticeship programs were set up. A pilot project, based on home study, was implemented to make the transition easy for women. This study plan is tailored to personal needs to allow for a balance between family responsibilities and career advancement.*

*The recognition of daycare concerns prompted the company to purchase priority spaces through company donations at a local facility. Experiments in job sharing have also been beneficial to both the employers and employees.*

*This sensitive approach to employees has been extended to other company programs including maternity leave.*

*For these efforts, Edwards was recognized by the Ontario Women's Directorate in 1988 with the Employment Equity Award.*

*With reference to health and safety issues, it is corporate policy to provide an enlightened, caring, work environment for employees. RSI (repetitive strain injury) has been a great concern for both the employers and employees. Escalating healthcare costs along with little factual information presented a serious problem with hidden causes. It was identified that RSI was a large part of the compensation claims involving women.*

*The combined efforts of management, human resources staff, and engineering personnel were not able to identify or correct this situation with existing resources. Thus, an ergonomic study was commissioned in consultation with the Ontario Women's Directorate. This study provided factual data; revealed many of the causes of RSI; and, presented recommendations to improve the work environment at Edwards.*

*It is joint projects such as this case study, with the cooperation of government, labour, and employers, that creates an awareness in both the public and the private sectors. By promoting programs that employ the considerable talents of employees working in harmony with their workstations and environment, greater benefits will be derived as the private sector competes effectively in the global marketplace.*

**Manager, Human Resources**

**Vice President, Manufacturing**

# Introduction

Of all the risks and hazards that employees face in the modern workplace, few have been as misunderstood as repetitive strain. Virtually unheard of ten years ago, repetitive strain injuries are common today in workplaces throughout the country.

Repetitive strain injury (RSI), also called occupational overuse, is a generic term used to describe a range of soft tissue disorders including carpal tunnel syndrome, tendinitis, and bursitis. Caused by holding unnatural positions or sustaining repetitive motions over long periods of time, RSI results in painful wrists, elbows and shoulders, numb fingers, and difficulty grasping.

Unlike overexertion, however, which usually results in strains and sprains, overuse symptoms can become chronic, and treatment is limited.

***In case studies, companies can find concrete examples showing how repetitive strain can be understood, addressed, and ultimately, beaten.***

In an effort to curb the sharply rising incidence of RSI among its workforce, Edwards, a manufacturer of fire alarm systems and components, commissioned a detailed ergonomic study of the assembly area of its Owen Sound, Ontario plant. The study, carried out in partnership with the Ontario Women's Directorate through the Change Agents program, identified high-risk jobs, examined tasks and workplace conditions that contributed to RSI, and made recommendations aimed at reducing the problem at Edwards.

This report is divided into three parts. The first part discusses RSI in the context of today's workplace. It will dispel some of the myths that surround this enigmatic injury and discuss some of its causes, treatments and cures. The second part looks at the methods used by the researchers to identify leading causes of repetitive strain injury at the Edwards plant. Finally, in the third part, this report summarizes the findings of the consultants and the recommendations they made.

The Edwards study presents a model case that provides concrete examples of how relatively simple ergonomic intervention can be used successfully to head off potentially devastating RSI problems. It is hoped that other companies will benefit from the efforts Edwards has made to understand, address, and ultimately beat repetitive strain.

# I. Repetitive Strain: Fact and Fantasy

For decades repetitive strain injury (RSI) has been quietly taking its toll in Canada's shops, factories and offices while employers, supervisors, and even sufferers themselves, have often looked the other way. It seems almost to be a conspiracy of silence: unskilled workers, fearing the loss of their jobs, have been reluctant to complain; employers, not wanting to bear the huge burden of compensating RSI sufferers, have been slow to admit that the symptoms could be job-related; and government, not familiar with the factors affecting RSI and industry, haven't fully recognized the true impact of it.

But after a decade of research on the causes and effects of RSI, the jury is in and the verdict is that

***Repetitive strain injury is not a function of gender, but rather of the roles women have traditionally played in the workplace.***

conditions at work are indeed a leading cause of RSI. Today, as a result of this research, thousands of RSI sufferers are receiving the compensation benefits they deserve. But this is hardly cause for celebration -- especially when one considers how easily those injuries could have been prevented in the first place.

Basically, in their examination of RSI, medical researchers have given us good news and bad news. The bad news is that RSI, often misdiagnosed as arthritis, is a frequently chronic, potentially debilitating condition. If the strain is not alleviated, the symptoms worsen and eventually become irreversible. The good news is that alleviating the strain is a relatively simple process and one that can be accomplished in any workplace.

And the good news doesn't end there either. Employees, free of overuse-induced pain, will be more productive, spend more time at their workstations, and generally feel better about their jobs.

There is one relationship, however, that medical science has failed to prove -- women and RSI. While statistical evidence indisputably links RSI with women, clinical evidence thus far has failed to do so.

The reason for this conundrum has to do with the demographics of today's workplace. Typical high RSI-risk jobs include clerical work, data input, textile and electrical assembly. It is no coincidence that these are also occupations dominated by women. RSI then, is not in all likelihood a function of gender, but rather of the roles women traditionally play in the workplace.

It's also interesting to note that in their domestic roles, women have pounded, beat, kneaded, scrubbed, and churned their way through the ages. Perhaps the widespread reluctance to accept RSI as an occupational injury stems from the fact that these associated symptoms came to be thought of as just part of being a woman.

***Quotas, ill-conceived bonus schemes and other workplace pressures only exacerbate the problem by pushing employees beyond their limits.***

Today however, thanks to labour-saving devices around the home, RSI most frequently finds its source at the workplace. This isn't hard to believe when one considers the pace at which many manufacturing facilities operate. At the same time, quotas, ill-conceived bonus schemes and other workplace pressures only exacerbate the problem by pushing employees beyond their limits.

But RSI is not a predictable occurrence. Nor are all workers alike. Some will suffer the effects much earlier than others. There may be a reluctance to admit discomfort, or language may act as a barrier to communication. Whatever the situation, responsible employers will look for the warning signs of RSI. They will be aware of its causes, ensure that adequate medical attention is provided, and seek the advice of qualified ergonomists and occupational medical practitioners when necessary. The following case study offers a look at the kind of details professionals examine in order to assess an RSI problem, and the solutions that can be implemented to correct it.

## II. Taking Aim

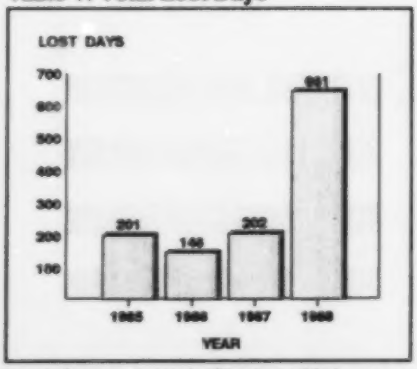
Quite often, deciding what to study can be as big a problem as actually studying it. In the manner of all good scientific research, the Edwards study slowly and methodically worked its way from the general to the specific. Starting with the big picture, researchers first looked at the plant as a whole, and gradually narrowed their fields of study, homing in on the trouble spots that had the most to gain from ergonomic intervention.

Two departments were eventually singled out in this manner: the devices assembly department and the printed circuit boards assembly department. Together they provided ideal subjects: both were experiencing high injury rates; both had high percentages of female workers; and, both were the sites of repetitive strain injuries.

Once these problem areas had been identified, the consultants set about a detailed ergonomic audit that included measurement and analysis of workplace conditions. Then, armed with the results of their observations, and equipped with an expert knowledge of the field of ergonomics (how humans interact with their physical environment), these ergonomists tabled recommendations they felt would overcome the problems. Here's how they did it.

The study started with a hard look at the plant as a whole. Looking for areas likely to have statistically significant injury rates, researchers began by examining the type of work that was being done, the movement of goods and products, the rate of production, and other factors that could have a bearing on workplace injury. Specifically, they were out to determine which of the many links in the manufacturing chain were particularly active and labour-intensive.

**Table 1: Total Lost Days**




**Lost days are an indicator of injury severity. The number of days lost to injury at Edwards rose nearly 300 per cent in 1988 and over 80 per cent of those injuries were due to repetitive strain.**

At the same time, they conducted a thorough examination of injury records at the plant (mostly from WCB Form 7 accident reports) and other statistics. These statistics, which spanned four years, included yearly totals for the number of hours worked, the number of compensable incidents, WCB costs, and lost days due to injury.

Narrowing the focus of their examination even further, the researchers then turned their attentions to the records of five active and busy departments. Examining total lost days and total incidence, they compared the figures of these departments with one another, as well as with those of the plant as a whole

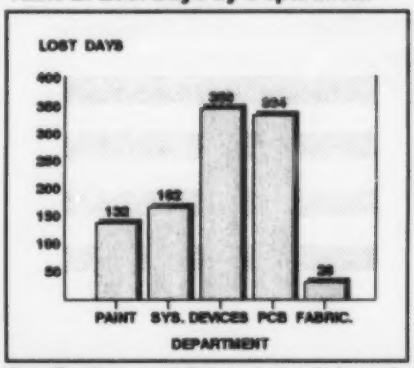
(see Table 1 on page 7). It wasn't long before a pattern developed.

It was found that two departments in particular were sustaining serious injury problems (see Table 2). A closer look at the culprits revealed that upwards of 42 per cent of their WCB claims were attributed to repetitive strain (see Table 3). The departments in question were the Devices department, where small appliances such as clocks, bells, and pull stations are assembled, and the Printed circuit boards department, where electronic components are checked and assembled on printed circuit boards.

Finally, ergonomic checklist in hand, the researchers carried out a brief review of each workstation in these two departments -- nearly one hundred in all. The checklist provided a general review of ergonomic factors that could have a bearing on injury risk. These factors included the state of the physical environment, the organization of the tasks, and the activities necessary to carry them out. Each job was then scored according to its level of stress or ergonomic concern.

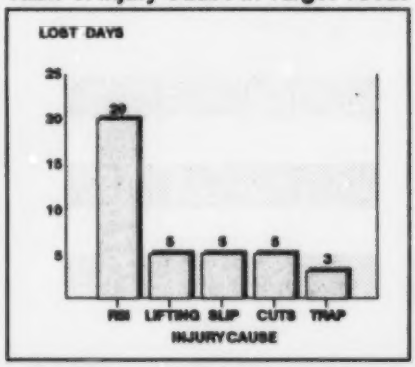
Once all the results were in and the data collated, it didn't take much analysis to spot the common thread that seemed to run through the vast majority of RSI injuries: benchwork. Benchwork is common in electronics manufacturing. It involves the assembly of small components at a worktable and requires precise movements repeated over and over. Not surprisingly, the principal method of assembly in the Devices and Printed circuit boards departments was benchwork.

**Table 2: Lost Days by Department**




**The Devices and Printed circuit boards departments experienced the highest number of lost days over the four year period. At 90 percent, they also had the highest proportion of female workers.**

**Table 3: Injury Cause in Target Areas**




**In the Devices and Printed circuit boards departments 92 per cent of all injuries were incurred by female workers; 42 percent of those were attributable to repetitive strain.**

***Unless early action is taken, repetitive strain will inevitably result in serious medical problems and lost time claims.***

In their report, the consultants concluded that "analysis of both departments indicated that most injuries were repetitive strains to the upper limb resulting from benchwork jobs." They went on to warn that, "this type of disorder tends to increase in severity with continued exposure to occupational stressors, ultimately resulting in medical aid and lost time claims."

But identifying the problem is only half its solution. To finish the job, the consultants advised a full ergonomic assessment that included workable recommendations for correcting problems with benchwork. The following section outlines their methods and summarizes their conclusions.

## III. Hitting the target

Much like a tax audit, which looks for financial inconsistencies, or a health and safety audit, which is used to spot workplace hazards, the ergonomic audit is intended to uncover areas where people and equipment enjoy a less-than-harmonious relationship. At Edwards, full-scale ergonomic audits were carried out for critical tasks among benchwork jobs in the Devices and Printed circuit boards departments.

The researchers defined critical tasks as "those having either significant human factors (ergonomics) concerns, or those critical to the successful operation of the (manufacturing) system." These included tasks that employed the use of hand tools, tasks that required turning to one side, and, of course, tasks that are repetitive or stressful in nature.

For each critical task, every movement was evaluated in terms of sensory, cognitive, physiological, and biological requirements. Also examined were environ-

mental conditions (heat, noise, vibration, etc.), learning requirements, and organizational factors. It was this information that the consultants eventually based their recommendations on.

A typical task analysis consisted of the following:

- interviews with a cross-section of the workforce, including supervisors;
- observation of each job for a minimum of one complete shift;
- measurement of relevant worksite dimensions;
- an analysis of body movements that contribute to postural stress;
- a computer analysis of worker musculo-skeletal stress; and,
- a comparison of environmental conditions with accepted standards.

In addition to this, a whole body discomfort survey was distributed to workers in the targeted areas. This survey required workers to indicate the level of physical stress or discomfort they experience at the end of a typical shift. The survey covered 15 different parts of the body.

For the researchers, the discomfort survey hinted at the demands being placed on the workers from day to day. For Edwards management, it provided an indication of the number of employees who could end up on the compensation roles due to RSI. Necks, shoulders and wrists were the most common discomfort zones, with the vast majority of those polled indicating some stress in these areas (see Table 4).

**Table 4: Discomfort Data**

| BODY AREA | DEVICES (%) | BOARDS (%) |
|---|---|---|
| Head | - | 65 |
| Eye | 7 | 61 |
| Ear | 7 | 22 |
| Neck | 64 | 78 |
| Shoulder | 71 | 74 |
| Upper arm | 14 | 52 |
| Upper back | 36 | 61 |
| Lower back | 50 | 74 |
| Elbow | 14 | 52 |
| Forearm | 29 | 43 |
| Groin/Buttocks | 7 | 26 |
| Wrist | 50 | 70 |
| Fingers | 43 | 61 |
| Upper leg | 14 | 26 |
| Knee | 29 | 22 |
| Lower leg | 14 | 22 |
| Ankle | 21 | 13 |
| Foot | 14 | 57 |

**The percentage of workers in the two target departments who complained of discomfort hinted at the extent of the RSI problem.**

**Department Overview**

The consultants began their audit with a look at the general structure of the two departments and how the jobs within them are organized. They found that the Printed circuit boards and the Devices departments had a lot in common. Both were dominated by benchwork jobs, both were staffed almost exclusively by women and both produced similar results on the discomfort survey.

While most production in the departments is in small batches, specific job tasks within each area tend to include similar activities and demands. What this means is that, contrary to the old saying, a change is *not* always as good as a rest.

**Benchwork Task Description**

Benchwork tasks within the two departments vary from complete component parts assembly and packaging at a single workstation, to sequential sub-assembly tasks at several workstations in an assembly line arrangement. Individual workstations are laid out in advance by a Lead Hand who ensures that a completed sample of the finished product and all the component parts are on hand.

A typical workstation is arranged with a cart containing unfinished goods to the left, and a similar cart for finished goods to the right. The bench itself is a flat, level surface. Lighting comes from above. Tools used at the benches include pliers, cutters, screwdrivers, and soldering irons. In the Devices department, pneumatic tools hang above the work area from spring-loaded balancers.

Component parts tend to be small and light. These, and the hand tools, are laid out by the workers according to their personal preference. Although general time standards for assembly tasks do exist, work pacing tends to be minimal.

The following is a typical sequence of bench assembly tasks:

1. Retrieve an unfinished unit from the left cart by reaching with the left arm;
2. Position the unit in the work area (flat on the bench or oriented into a purpose-built jig);
3. Retrieve component parts from the parts bins by reaching with either arm (often both), and grasping with a pinch grip;
4. Position parts for assembly;
5. Secure fasteners with tools or a soldering iron;
6. Repeat steps 3, 4, and 5 until the assembly is complete;
7. Test and inspect the unit; and,
8. Place the finished or sub-assembled unit on the right-hand cart by reaching with the right arm.

Several assembly tasks require the use of a jig to position and secure the work during assembly. All jigs rest on the bench surface and orient the work on the same plane as the benchtop. In some cases, several units are loaded into one jig for batch assembly.

**Analysis and recommendations**

The final phase of the study involved a detailed analysis of benchwork jobs in both departments. This analysis was used as the basis upon which specific recommendations for ergonomic intervention were based. This phase looked at six aspects of benchwork

which raised ergonomic concerns. These are:

-horizontal reach requirements;
-vertical reach requirements;
-postural factors;
-upper limb concerns;
-environmental factors; and,
-workspace furniture and layout.

## 1. HORIZONTAL REACH REQUIREMENTS

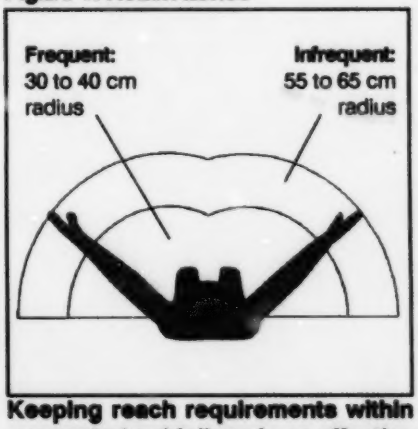
**Analysis**

The researchers found that component parts bins tended to be randomly located about the central work area 30 to 80 cm from the worker. Jigs and handtools were arranged 25 to 50 cm in front of the worker, and storage carts were 60 to 100 cm to either side and behind the worker.

Infrequently accessed items should not be placed outside a 55 to 65 cm radius from the shoulder (see Figure 1). The researchers found that the storage carts and some parts bins used in the two departments were located well outside this range, requiring extensive torso bending and twisting when the workers were reaching for them. Since the storage carts are located behind the worker, the shoulder joint must also move to the extreme of the range of movement during the reach.

Frequently accessed items (jigs, tools, and component parts) should be located within a 30 to 40 cm radius (see Figure 1). It was found that most benchwork items were located outside this limit, contributing, says the study, "to localized muscular stress in the shoulders and back."

**Figure 1: Reach Zones**




**Keeping reach requirements within suggested guidelines is an effective means of reducing stress to the shoulders and back.**

Figure 2: Storage cart

**Sloped, adjustable storage carts reduce the amount of reaching and bending required.**

**Recommendations**

The consultants advised that all items to be handled by workers performing benchwork be positioned within the ranges indicated in Figure 1. To that end, they offered the following suggestions.

1. Storage carts should be angled so that layers of parts are oriented towards the worker (see Figure 2). This would reduce the extent of reaching and torso bending. The height of the cart should be adjustable so that, with the parts container angled at between 30 and 45 degrees, the bins come even with the range between the worker's knuckle and shoulder. Each parts row on the cart should be separated by a ridge or bracket to maintain parts in place at high angles.

2. The workstation should be reconfigured so that all parts on storage carts can be accessed within the 180-degree reach zone of the seated worker. In this case, reaches behind the line of the shoulders would be eliminated and torso twisting and stress to the shoulder joint would be reduced.

3. In the Devices department, the consultants noted that jig size often dictates where component parts bins can be located. Wide or deep jigs, they found, require a worker to adopt leaning, reaching postures in order to access all units from one seated position. To counter this tendency, they advised that the width and depth of jigs be limited, or that the way they're arranged be modified.

"Most batch assembly jigs are configured either as one wide row or two deep rows, thereby placing components at the extent of reach," said the researchers.

"Jigs could be arranged in a rotating, circular configuration (like a lazy Susan), which would limit the width of the jig and place each unit directly in front of the worker during assembly."

4. It was discovered that, in many cases (after the available area within the frequent reach zone had been filled), component parts and bins could be stacked vertically. The consultants warned, however, that bins should not be stacked above shoulder height. This would limit the stress to the shoulder joint.

5. Finally, it was suggested that Lead Hands and supervisors be trained in ergonomic factors associated with workspace layout. "This would reduce reach concerns created when setting up a job," read the final report.

## 2. VERTICAL REACH REQUIREMENTS

### Analysis

Vertical reach was found to be a particular problem in the Devices department, where pneumatic tools are suspended from overhead rails. Frequent reaching above shoulder height is undesirable and should be avoided. The consultants noted that in most cases, the tools were suspended at or below shoulder level.

### Recommendation

Though vertical reach requirements were generally acceptable, it was recommended that all suspended tools be brought within a comfortable grasping height of no more than 30 cm above the worksurface.

## 3. POSTURAL FACTORS

### Analysis

The researchers uncovered three problems that had to do with the postures workers had to adopt. First, they found that in both departments, benchwork takes place on a flat worksurface. The work, they noted, requires fine manipulation with the visual target well below the natural line of sight. The result was that workers had to adopt postures that put extreme stress on their necks. This stress accelerates neck muscle fatigue and causes discomfort, not only in the neck, but in the upper back as well.

Second, in order to orient their tools and soldering irons under benchwork conditions, workers had to strain and elevate their arms -- often more than 45 degrees -- for prolonged periods of time. This lifting of the arms results in static loading to the muscles of the shoulder, which causes localized fatigue and discomfort.

Finally, in the Printed circuit boards department, jigs used for inserting components into printed circuit boards orient the board surface level with the worksurface. During insertion of components, the worker must be capable of visually guiding the component leads into the tiny insertion holes in the board. While observing these tasks, the consultants noted that the component itself obstructs the worker's view of the insertion holes. To compensate, workers tended to flex their necks to one side so they could see around the component. This put the worker's neck under extreme stress, causing pain and fatigue.

**Recommendations**

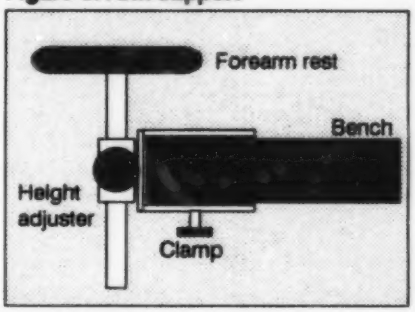
1. It was recommended that all work requiring visual discrimination be located within 40 degrees of the horizontal line of sight. For the Printed circuit boards department, the consultants recommended that neck flexion (to see around components during insertion) be limited to within 15 degrees of the vertical plane.

To this end, the consultants recommended that all visually discriminating work be angled and elevated. "Jigs should be angled towards the worker," they wrote. "For benchtop work, a sloped worksurface area should be constructed." They also suggested that both the height and the angle of the worksurface be adjustable.

2. To address the second problem outlined in the analysis above, the consultants advised that support for the arm be provided during activities that require it to be lifted higher than 25 degrees from the side of the body. A conceptual design for such a support appears in Figure 3. It calls for a forearm rest secured to a central post that is adjustable in both height and angle. The table mounting-bracket is meant to be portable between workstations.

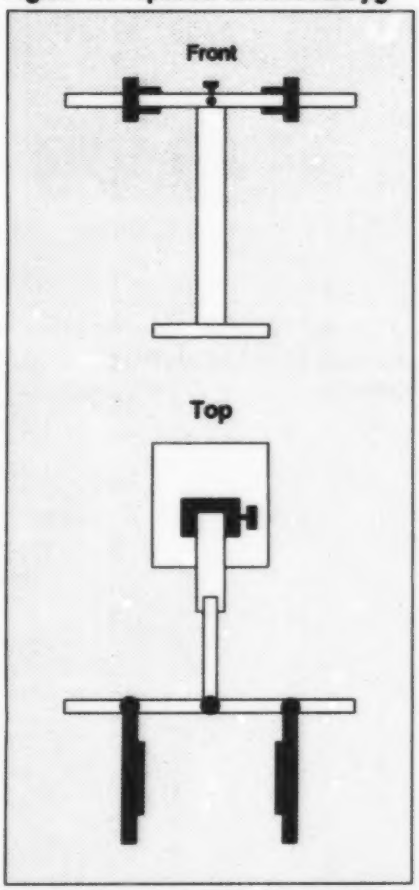
3. To overcome the difficulty faced by workers in the Printed circuit boards department who must twist their necks to see around the components they are inserting into the boards, the consultants suggested that this work be carried out within 15 degrees of the vertical plane. To do this, they proposed a jig that would hold the board steady, but allow the worker to turn it easily in order to see where the leads align with the holes in the printed circuit boards (see Figure 4).

**Figure 3: Arm support**




**Support for the arm is crucial when tasks require it to be lifted more than 25 degrees.**

**Figure 4: Proposed circuit board jig**




**Turning their work, instead of holding it stationary, allows workers an unobstructed view without making it necessary to bend their necks.**

This would reduce the stressful neck and upper limb postures.

4. Finally, it was suggested that visual demands be reduced by making sure that all benchworkers undergo regular vision tests. Workers requiring corrective lenses or changes to an existing prescription should be encouraged to have them looked after. The consultants also recommended that a magnifying lens be provided to increase target size. They warned, however, that workers occasionally complain of nausea when required to perform visual work that moves frequently in and outside the lens field. "Care should be taken to train workers in the advantages of using a magnifying lens and to limit frequent visual work outside the lens field," they cautioned.

## 4. UPPER LIMB CONCERNS

### Analysis

It was found that benchwork assembly tasks are typically short resulting in high repetition rates of fairly unitary work activities. Workers must often employ a forceful grip when handling tools. Pneumatic tool use often required the application of considerable downward force to ensure the fastener was secure. In fact, several workers were observed exerting forceful wrist flexion to further secure a fastener after the torque limit of the tool had been exceeded.

In the Devices department, the problem was exacerbated by worn tool bits. Worn bits tend to slip out of the fastener head, requiring workers to apply greater downward force to the tool. These high forces can also result when pneumatic tools seat a fastener and transfer the torque to the worker's wrist.

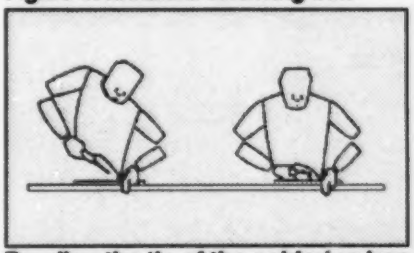
Repeated stress and prolonged exposure to these kind of forces combine to damage tendons and tendon sheaths. The result is inflammation, reduced strength, and decreased range of joint movement. Continued stress to these damaged areas can escalate to permanent tissue and nerve damage, resulting in loss of strength and feeling in the affected areas.

Meanwhile, in the Printed circuit boards department, printed circuit boards not placed in jigs were frequently secured by pinning the board against the worksurface with the base of the hand or forearm. The researchers noted that typically, workers must adopt postures that require extreme joint angles in the wrists and shoulders. This application of highly repetitive, forceful exertions at extreme joint angles is known to contribute significantly to the development of repetitive strain injuries such as tendinitis, synovitis, and carpal tunnel syndrome.

**Recommendations**

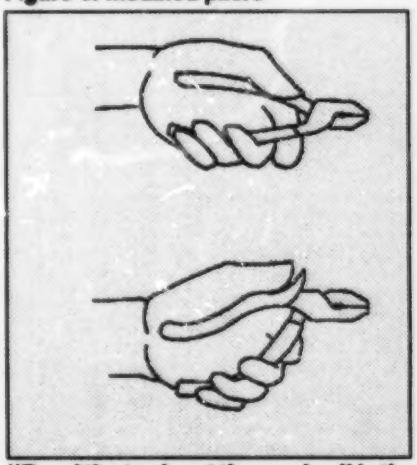
1. The ergonomists recommended that the wrist angles required of workers be limited to the central third of the normal range of movement. To do this, they proposed the use of tools designed to keep the joints of the upper limb in a generally neutral posture. Figures 5 and 6 illustrate two such examples. The consultants also recommended that the workpiece be oriented towards the worker. This, they claimed, would minimize the extent of upper limb and neck posture deviation (from neutral). The researchers recommended that these two measures be carried out together. "The choice of tool and the orientation of the workpiece will be interactive," they pointed out. "Change to one will affect the suitability of the other."

**Figure 5: Modified soldering iron**



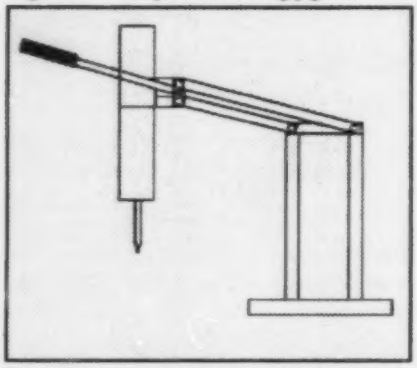
**Bending the tip of the soldering iron overcomes the stressful raised-shoulder stance.**

**Figure 6: Modified pliers**



**"Bend the tool, not the worker" is the popular maxim demonstrated above.**

**Figure 7: Torque-arresting jig**



**Torque-arresting jigs and other such devices are designed to absorb the inertia built up in a spinning tool bit.**

2. Regular job rotation was suggested as a means of reducing the duration and frequency of stress to joints in the upper limb. All rotation schemes, however, should be carefully planned to ensure that workers are rotating to jobs that do not stress the same muscles and joints as their present jobs.

3. It was suggested that the amount of force required during tool gripping be reduced, particularly where pneumatic tools are concerned. The researchers found that tool torque caused a considerable amount of stress to the upper limb of workers in the Devices department. Tool torque is often the highest at the moment the fastener seats. Installation of a torque arrest system would reduce this stress. Several arrest systems were suggested, including adjustable clutch mechanisms such as those found in newer pneumatic tools, and torque-arresting brackets or jigs such as the one illustrated in Figure 7.

4. Finally, the researchers recommended a program of regular tool bit maintenance to ensure bits are replaced. They advised that fastener head types also be reviewed to determine which are best suited to low torque tool use. For example, the Robertson head requires low torque and shows minimal bit slippage.

## 5. ENVIRONMENTAL FACTORS

### Analysis

**a) Temperature.** Temperatures of about 26 degrees Celsius were measured at several workstations on a particularly warm day in August. While these values were within permissible heat exposure threshold limits for light work as recommended by the American

Conference of Governmental Industrial Hygienists (ACGIH), they did exceed the limits of thermal comfort. This could have adverse effects on the performance levels of the workers. During hot days, however, workers were given two additional afternoon breaks and provided with cold drinks.

**b) Lighting.** Illumination levels at various bench worksurfaces ranged between 800 and 1000 lux. The Illuminating Engineering Society (IES) recommends illumination levels of between 1000 and 2000 lux for fine assembly and difficult inspection work, up to 5000 lux for very difficult inspection work.

**c) Vibration.** Workers operating pneumatic tools during benchwork were found to be exposed to intermittent bouts of high frequency vibration of moderate amplitude (severity). Continuous exposure to high frequency hand/arm vibration has been linked with a sensory and motor disorder to the hands (vibration white finger disease). Symptoms of this disorder include loss of grip strength and tactile sensitivity, and is often associated with Carpal Tunnel Syndrome. It is also often accompanied by bouts of finger or whole hand blanching brought on by mild stress, cold, or noise.

**d) Noise.** Ambient continuous noise levels ranged between 70 and 80 dBA (decibels with harmful frequencies emphasized). Use of pneumatic tools and riveting equipment produced intermittent noise levels between 80 and 85 dBA. These levels fall within the accepted ACGIH guidelines for an 8-hour workday.

**Recommendations**

**1. Temperature.** The consultants found no real problems with the way the high temperatures were being handled. However, they did suggest some additional considerations such as controlling humidity levels, using fans to increase air flow at workstations, and training workers to identify early signs of heat exposure.

**2. Lighting.** It was suggested that local task lighting be provided at each workstation to increase illumination to the recommended levels. This form of lighting is recommended over increasing general lighting levels because it cuts down on glare and contrast.

**3. Vibration.** The consultants offered the following suggestions to minimize vibration to arms and hands:

- install vibration-damping covers on the handles of pneumatic tools;
- purchase only low-vibration tools in future;
- reduce the duration of exposure to vibration by introducing regular job rotation to jobs without vibrating equipment.

## 6. WORKSPACE FURNITURE AND LAYOUT

**Analysis**

**a) Seating.** Two seating alternatives were available to benchworkers: a padded, adjustable pedestal chair and a metal, non-adjustable chair without padding. Foot support was limited and non-adjustable. Although the padded chair provides greater point pressure comfort, according to the consultants, "both chairs fall well short of the ideal." A suitable chair, they reported, should provide adequate support and

comfort to the legs and back. Adjustability is critical for ensuring that different body sizes can be accommodated. Inadequate leg support causes high point pressures to the back of the thighs and knees, resulting in reduced blood flow in the lower limbs, fatigue, and discomfort.

**b)Worksurface.** Each worksurface is a flat benchtop with a wooden surface and angle-iron frame. Average worksurface height was about 88 cm. The recommended worksurface height for seated light assembly tasks is adjustable between 82 and 87 cm.

**c) Layout.** Several workstations appeared congested and did not provide sufficient work area for the tasks. Some workstations included obstructions under the worksurface. Inadequate workspace results in clutter. Obstructions under the worksurface can cause contact injuries. Workers often adopted uncomfortable seated postures to avoid these obstructions, thereby increasing the onset of fatigue and discomfort.

**Recommendations**

**1. Seating.** The ergonomists suggested two solutions to the seating problems. First, provide adjustable seating to support the legs and back with sufficient padding to limit point pressure discomfort. Second, provide an adjustable footrest at each workstation to relieve blood flow restrictions in the lower limbs and to allow for leg position changes to reduce discomfort.

**2. Worksurface.** All worksurfaces should be adjustable between 82 and 87 cm was the only suggestion on this count.

**3. Layout.** A benchtop work area should have a minimum width of 150 cm to allow room for adequate reach and storage clearance, said the consultants. They went on to urge the removal of all leg obstructions under the worksurface, including posts, equipment, etc. Knee clearance, they suggested, should be a minimum of 46 cm, and leg clearance, at least 100 cm from the front of the bench.

## III. Conclusions

The consultants concluded that reports of discomfort are often the precursor of more serious musculo-skeletal concerns that can result in increased medical aid and lost time claims. This is particularly true with repetitive strain disorders, which develop progressively from mild inflammation and discomfort, to painful swelling, and in severe cases, to nerve dysfunction resulting in reduced strength, range of movement, motor control, and tactile sensitivity.

Workers experiencing discomfort will engage, often unconsciously, in micro-absenteeism. Micro-absenteeism results when workers leave their workstation more often than is necessary (e.g., frequent washroom visits, repeated trips to restock their workstations, etc.). Leaving the workstation allows the worker to rest the affected body parts and momentarily reduce discomfort. Discomfort can also affect the posture that a worker will adopt during work. The workday is usually started in the most productive posture. As discomfort

***The three crucial elements of successful ergonomic intervention are planning, testing, and communicating.***

increases, less productive postures are assumed to rest affected body parts.

Several intervention strategies have been recommended to improve worker well-being and performance in these jobs. Although individual recommendations have been provided for specific concerns, successful workplace design often relies on the successful integration of several recommendations together. For example, installing the circuit board jig will reduce extreme neck and wrist angles, but will require workers to keep their arms raised longer. Therefore, the success of this intervention relies on the installation of forearm supports as well.

Successful implementation of these recommendations requires that an ergonomist work with the implementation team (engineers, fabrication shop workers, supervisors, and line workers) to ensure that design concepts achieve their ergonomic objective without compromising work well-being or performance. Also, design interventions should be prototyped and reviewed by the implementation team prior to evaluation at a workstation. Finally, after modifications have been implemented at a workstation, worker feedback, well-being, and performance, should be monitored, and interventions modified as necessary.

# Epilogue

This cooperative project between Edwards and the Ontario Women's Directorate has resulted in achieving both the ergonomic assessment of our industrial setting and identifying the areas of ergonomic concern throughout the plant. From "Taking Aim" to "Hitting the target" to "Implementing the Recommendations," this paper has chronicled a methodical approach to ergonomics in the workplace. The industrial setting at Edwards involves many labour-intensive operations with employees seated and/or standing at workbenches during most or all of their shifts. The workplace here, and the conditions in it, is representative of many production facilities throughout the province.

Since the completion of the ergonomic assessment by Human Systems Inc., Edwards has established an ergonomic plan to implement the recommendations outlined in their final report. This has been accomplished in a systematic manner using available resources efficiently and effectively. As we progress, the plan is revised to more closely match the recommendations with the changing conditions in the workplace. Training of the supervisory

staff has been completed, and plans are in place to train lead hands and setup personnel as well. Ongoing training is also being considered for all employees and engineering staff.

But training alone will not solve the problem. Experimental work on chairs, footrests, armrests, and work-holding fixtures by engineering staff is an ongoing endeavour. In the meantime, portable scissor-lift tables have been purchased and set up throughout the Devices and Printed Circuit Board departments. The results so far have been excellent.

From the medical perspective, the company physician now reviews the ergonomics-related compensation claims with engineering staff. This provides an excellent opportunity to take a preventative approach to workplace injuries. To gain the total health picture as far as injured workers are concerned, the company physician consults with the injured employee's personal physician. This allows for better comprehension of the claim's circumstances and effective treatment. It has also resulted in better communications between the physicians in the community and support staff at Edwards.

In conclusion, the exercise has been a learning experience for everyone involved. The Change agent Program, sponsored by the Ontario Women's Directorate, has provided Edwards with the vehicle to access professional resources outside the company. It has also identified the true impact of ergonomics in the workplace. Now Edwards is better able to implement the remaining recommendations, thereby improving the workplace for women, while at the same time competing effectively in the global marketplace.